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Comparative study of RC framed Multistorey Structure with and without Infill Brick Masonry in EQ zone IV for Hotel building

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Abstract

Masonry infill is important part of any structure which provides strength and stiffness to buildings with many secondary facilities. However it is found that masonry is not provided in many commercial buildings like hotels, offices etc. in some floors of buildings for various purpose like parking, conference rooms, restaurants, cafeteria and for many more purposes. But it has been found that elimination of masonry affects in building strength and durability in many forms. In this study the behaviour of fly ash brick masonry infill panels in reinforced concrete structures is analyzed. Six different models of ten storeyed building are analyzed for this purpose. First model is bare frame, Second model has masonry infill and third to sixth models represent elimination of masonry on different floors. These infill models are also analyzed with clay brick masonry to compare various aspects between these two types of masonry. The structure is evaluated using pushover analysis. The pushover curve is generated by pushing the node of structure to the limiting value of displacement and setting appropriate performance criteria. The target displacement is calculated as per FEMA-273 and the damage experienced by the building is found when subjected to ground shaking.Masonry infill panels enhance lateral stiffness of framed structures. Equivalent diagonal strut method is adopted for analysis of brick masonry infill panels as per FEMA-356 and Etabs software is used for analysis. Building is assumed as a hotel building which located is assumed in New Delhi. So the analysis criteria of seismic and wind are taken for Delhi zone. It is concluded that masonry infill panels should prefer in critical seismic zones than the open storeys. And for those buildings where it is required to have open storey than it should be on upper floors of building instead of bottom floors. Also it is found that fly ash brick masonry improve the strength of the masonry as well as better lateral stiffness than clay brick masonry infills.

Keywords: *Nonlinear static analysis, Structural safety, Etabs software, Pushover curve.*

Introduction

In India, reinforced concrete structures are widely used for buildings. In design of these structures, masonry infill panels are considered as a non-structural element. While in reinforced concrete structures, the presence of infill panels can increase the strength of the structure and behavior under lateral loadings. This increase in strength and overall stiffness is positive effect of presence of infill panels. The analytical model for masonry infill is represented by a single structural member which is called equivalent diagonal strut. The presence of masonry infill panel is studied by many researchers and various models are developed to understand the behavior of infill and proposed equivalent

diagonal strut model to contain the effect of infill. The objectives of present study is to investigate the lateral stiffness of the fly ash brick masonry infill frames, advantage of fly ash brick masonry over clay brick masonry in performance, lateral stiffness, strength and behavior of structure with & without open storeys in seismic zone IV. All infill models are analyzed first with fly ash brick masonry and then clay brick masonry and results are computed to investigate performance of both types of masonry in seismic regions.

Seismic analysis has been carried out by using Etabs software with IS code provisions and the procedure for nonlinear static analysis has been adopted as given

FEMA 273. Nonlinear static analysis (Pushover analysis) is useful for performance based seismic analysis to study the post yield behavior of structure. Nonlinear static analysis is more complex than the linear analysis, but it requires less effort and it deals with much less data than the nonlinear response analysis. Pushover analysis is performed on six different models of ten storey reinforced concrete structures with and without masonry infill panels. In this the permanent gravity loads is subjected to an incremental lateral load from zero to a prescribed ultimate displacement or until the structure is unable to resist further loads. The sequence of yielding, plastic hinge formation, displacements and storey drifts are noted and the total force is plotted against displacement to define a pushover curve or capacity curve.

Objectives

1. The objective of this research is to analyze six different models of ten storey structure in earthquake zones IV of India. And comparison between them to determine better lateral stiffness and strength.
2. All the models are analyzed with fly ash brick masonry infill and clay brick masonry infill to compare performance and lateral stiffness between both types of masonry infill panels.
3. Seismic data are taken from IS-1893 (Part-1): 2002 and Wind data are taken from IS 875 (Part-3): 1987.
4. Identification of the position of weak points in the structure (or possible failure modes).

Literature review

Mr. V. P. Jamnekar, Dr. P. V. Durge (2013) performedpushover analysis to find outeffects of unreinforced masonry infill on seismic behaviour of RC frame buildings. They observed that masonry infill have significant effect on dynamic characteristics, stiffness, strength and seismic performance of buildings as per IS: 1893-2002. Also, it was observed from the study that the without infill structure showed early formation of plastic hinges and structures failed at an early load stage itself whereas the partial infill 3D structure with brick infill showed a delayed formation of plastic hinge and improving the lateral capacity of the structure. The locations of plastic hinges are changed and generally the damage contributions in different storey are also changed, thus the infill walls prevents the damages concentrated in top storey and has a positive effect on damage contributions in all directions. As expected, the presence of infill can guarantee higher overall stiffness and strength, reducing the inter-storey drift demand of the structure.

Haroon Rasheed Tamboli and Umesh.N.Karadi (2012) performed seismic analysis has been performed using Equivalent Lateral Force Method for different reinforced concrete RC frame building models that include bare frame, infilled frame and open first storey frame. The results of bare frame, infilled frame and open first storey frame are discussed and conclusions are made. In modelling the masonry infill panels the Equivalent diagonal Strut method is used and the software ETABS is used for the analysis of all the frame models.

C.V.R Murty and Sudhir K.Jain (2000) investigated behaviour of masonry infill panels in reinforced concrete framed building. And found that masonry infill wall panels increase strength, stiffness, overall ductility and energy dissipation of the building. More importantly, they help in drastically reducing the deformation and ductility demand on RC frame members. This explains the excellent performance of many such buildings in moderate earthquakes even when the buildings were not designed or detailed for earthquake forces. The reinforcement in the infill does not contribute significantly towards stiffness and strength; in fact, it may lead to reduction in stiffness and strength due to increased mortar thickness in the layers containing the reinforcement. However, the reinforcement helps in improving the post-cracking behaviour of the masonry and in preventing out-of-plane collapse

Modeling and formulation of problem

Material and members properties

Properties of materials and members are shown in tabular form which is used in analysis.

Table 1Properties of material and members

Element	Material	Unit Weight (kN/m3)	Modulus of Elasticity (MPa)	Poisson's ratio	Compressive Strength (MPa)
Beam	Concrete (M-25)	25	25000	0.2	25
Column	Concrete (M-25)	25	25000	0.2	25
Masonry Strut	Clay Brick Masonry	20	3800	0.11	6.6
Masonry Strut	Fly Ash Brick Masonry	15.2	10470	0.15	10

Equivalent diagonal strut width

In concrete frames structures with masonry infills, behaviour of infills may be represented by equivalent diagonal braced frame as shown in figure 1. The behaviour of infill frame can be estimated by determination ofequivalentstrutwidth with the formula in equation 1& 2 is suggested by FEMA 273.

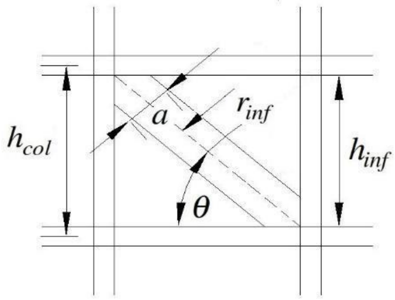


Figure-1 Equivalent diagonal strut model for calculation of 'a'

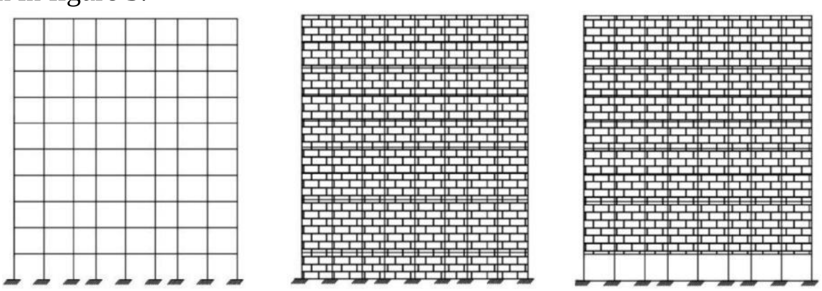
The elastic in plane stiffness of a solid unreinforced masonry infill panel prior to cracking shall be represented with an equivalent diagonal compression strut of width(a)given by eq.1. The equivalent strut shall have the same thickness and modulus of elasticity as the infill panel it represents

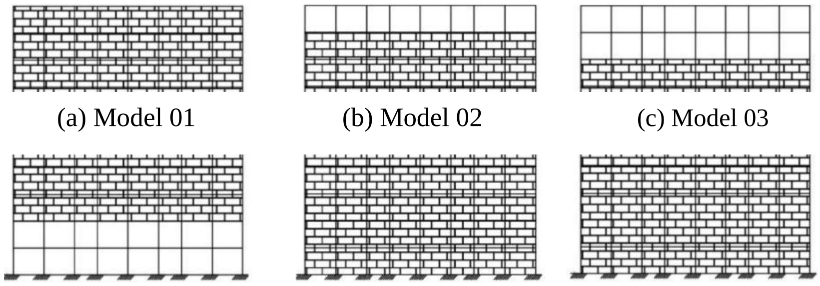
$$a = 0.175(\lambda_1 h_{col})^{-0.4} r_{inf} \quad \text{.........................(1)}$$

$$\lambda_1 = \left[\frac{E_{me} t_{inf} \sin 2\theta}{4 E_{fe} I_{col} h_{inf}}\right]^{\frac{1}{4}} \quad \text{.........................(2)}$$

Modelling

A symmetrical floor plan of ten storeys is considered for the modelling of all structures. Figure 2 shows all six models in which Model 01 is bare frame which has no infill panels on each storey, Model 02has infill panels on each storey, Model 03 has open first storey, Model 04 has open first and second storey, Model 05 has open tenth storey, Model 06 has open ninth and tenth storey. And plan of building is shown in figure 3.





(a) Model 01 (b) Model 02 (c) Model 03

(d) Model 04 (e) Model 05 (f) Model 06

Figure-2 Elevations of all models

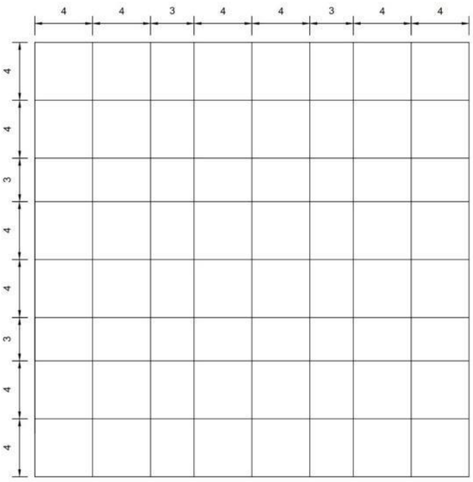


Figure-3Plan for all models

Structural analysis procedure

All models are analyzed by using Etabs software, steps involved in software are: defining geometry, material properties, member properties, defining loads, assigning loads, set diaphragm, defining nonlinear cases, assigning hinges, pushover Analysis.

Target Displacement (δ_t)

The target displacement is intended to represent the maximum displacement likely to be experienced during the design earthquake. In nonlinear static procedure, model directly incorporating inelastic material response is displaced to a target displacement, and resulting internal deformations and forces are determined.The target displacement δ_t for a building is given by the following equation 3

$$\delta_t = C_0C_1C_2C_3S_a$$

Results

All models are analyzed with the help of Etabs software and results are summarized by graphs, given below-

Pushover curve

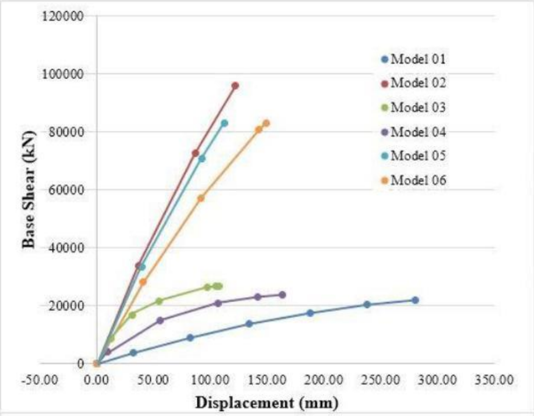


Figure-4Pushover curve for all models using brick masonry

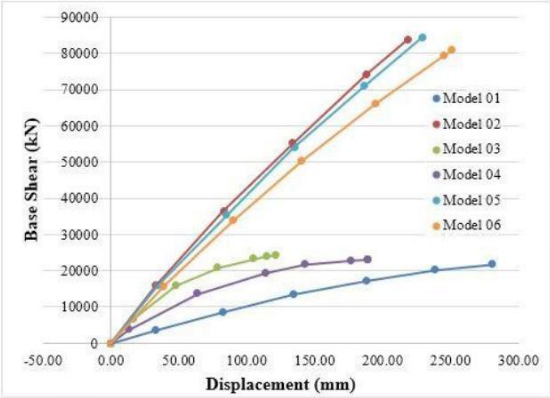


Figure-5 Pushover curve for all models by Fly ash using Clay brick masonry

Base shear and target displacements in CBM and FABM

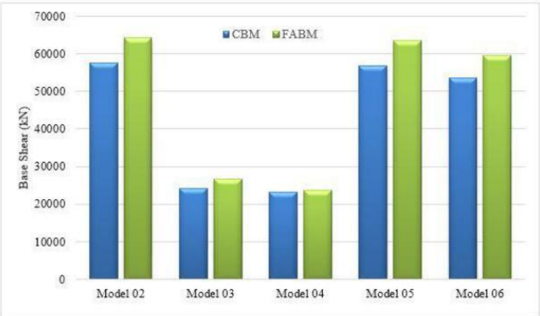


Figure-6 Base shear at target displacements for model 02 to model 06

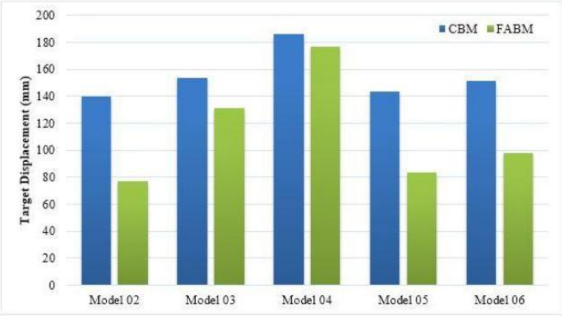


Figure-7 Target displacements for model 02 to model 06

Displacements and drifts in CBM and FABM in Model 02

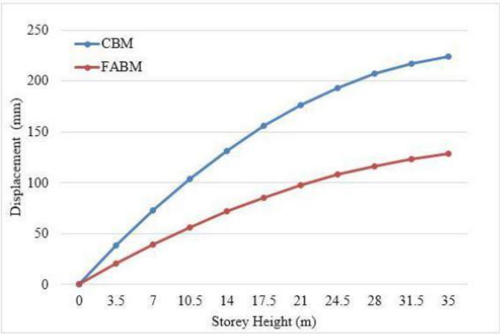


Figure-8 Displacement v/s Storey height

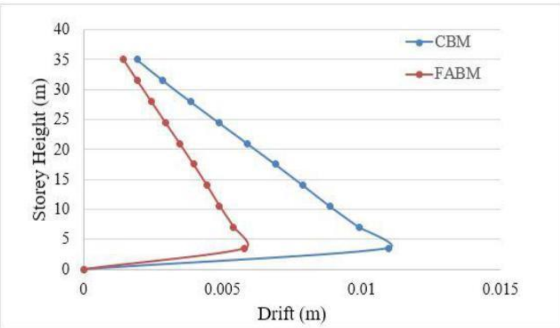


Figure-9 Storey drifts

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Conclusions

The parameters which are studies are base shear at target displacements, maximum displacements and pushover curves. Following conclusions can be made from the results:

(I) Comparison between models with and without infill panels: There are considerable difference in each models in the form of above given parameters.

1. The performance of infill frame is brilliant than without infill frames and hence there is considerable difference in displacement and lateral force along the storey height of building.
2. The time period of infill frame (model 02) is shortened than other models that indicates increased stiffness of the structure.
3. The storey drift of infill frame is very less than without infill frame. And storey drifts of lower open storey frames is very large than upper storey frames.
4. The maximum displacement of without infill frame is very large than full infill frame. And displacements of upper open storeys frames is less than lower open storey frames.
5. Hence the seismic analysis of structure should be done with masonry infill panels because it plays important role in lateral stiffness of structure. For modelling of infill panels, equivalent diagonal strut method is effectively used.
6. The presence of masonry infill panels affect the seismic behaviour of framed structure to large extent and it increases strength and stiffness of structure.

(II) Comparison between clay brick masonry infill and fly ash brick masonry infill frames: For comparison in clay brick masonry and fly ash brick masonry infill performance, model 02 to model 06 are analyzed with first with fly ash brick masonry infill and then with clay brick masonry infill panels:

1. The base shear at target displacement curve of fly ash brick masonry is performed better than clay brick masonry.
2. Target displacement of fly ash brick masonry is less than clay brick masonry.
3. The maximum displacement of fly ash brick masonry is less than clay brick masonry in each model.
4. Storey drift of fly ash brick masonry is found less than clay brick masonry.
5. Hence in high seismic regions fly ash brick masonry performance is found better than clay brick masonry in terms of storey drift and maximum displacement.

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